Vortons Revisited. Irreducible Inviscid Singular Represenation of 3D Fully Developed Turbulence and Related Emergent Physics.

M. I. Aksman

GISS, United States

*Corresponding author**: M.I. Aksman, GISS, United States, E-mail: maksman123@gmail.com

Abstract

- **Vortons introduced to approximate finite core vortex tubes and pass through Navier Stocks spontaneous singularities/reconnections without any additional assumptions.**

- **Vortons provide "singular decomposition" of vorticity field.**

- **Vortons have nonlocal 3D vorticity tails due to solenoid condition for vorticity. Superposition of vorticity in vorton chain produces finite core vortex tubes/filaments.**

- **They are not a weak solutions of Euler or Navier Stokes equations. Being more flexible singularities designed to pass through NS "singular events" based on inviscid singular dissipation Refs.[1-8].**

- **Vortons provide irreducible description of inviscid attractor of 3D Navier Stocks equation solutions with number of vortons scaling with Reynolds number at hand.**

- **Magnetic vortons provide irreducible description of magnetic vortex tubes in plasma with reconnections without any additional assumptions.**

- **Instability of quasi 3D/2D+ vorton collapse provides possible mechanism for explosive universe inflation/first order phase transition.**

- **3D space nature of our universe as a consequence of instability of 3D vortons collapse.**

- **"Dark matter" explained as a consequence of frisbee like quasi 3D/2D+ space in galaxies with corresponding stable rotational curves.**

- **"Dark energy" explained as a emergent result of vorton system 3D self amplification interaction energy "antigravity" effect.**

- **Probabilistic interpretation of quantum mechanics as a result of smooth test functions of fluid vacuum modified nonlinear Maxwell equations weak solutions.**

- **Baryon asymmetry explained as a instantaneous snapshot during exponential inflation of quark antiquark annihilation asymmetry/skewness and kurtosis terms in Edgeworth series expansion of instantaneous quantum GUP (generalized uncertainty principle) fluctuations.**

- **Quantum modified General Relativity QMOGER equations derivation physics proposed.**

- **Simple Early Bifurcation/Regime shift detection in nonequilibrium nonlinear statistical systems proposed using linear statistical moments/cumulants approximation/equivalents formulas.**

Keywords: Vortons, solenoid dipole singularities, 3D turbulence, vortex reconnections, inviscid dissipation, Navier Stokes attractor, instability of 3D vorton collapse, universe inflation, dark matter, dark energy, 3D physical space, emergent antigravity, probabilistic interpretation of quantum mechanics, nonlinear Maxwell equations, baryon asymmetry, Edgeworth series expansion, GUP generalized uncertainty principle, hemispherical power anomaly, statistical moments, skewness and curtosis, quantum modified General Relativity QMOGER .

Introduction

Navier-Stokes Solutions and Vorton Dynamics

The 3D Euler equations of incompressible inviscid fluid develop spontaneous singularities on timescales on the order of vortex rotations. Solutions to the 3D Navier-Stokes equations for incompressible viscous flow are smooth for all time, but they bifurcate and are not unique [1-8,29].

Vorton is the simplest solenoid 3D vortex singularity [1-5,29]. Finite core vortex tubes may be represented as superposition of vortons [1- 5]. Experimentally observed topological metamorphoses of vortex structures/reconnections could be seen in numerical vorton simulations without any additional assumptions. Vortons in plasma have magnetic dipole moments. Magnetic vorton tubes reconnect [1-5,14,29].

The 3D Navier-Stokes equations appear to have spontaneous singularities/reconnections and an inviscid vorton attractor that exhibits inviscid turbulence and dissipation with corresponding Kolmogorov like energy cascade towards small scale [1- 5, 10,29].

Original reasons for introduction of vortons were to resolve the most important structures for description of fully developed 3D turbulence, 3D vortex finite core tubes/filaments and ability to pass through spontaneous singularities of Navier Stokes equations, which turn out to be bifurcations/branching of solutions/reconnections of vortex filaments/tubes [1-5,29], Eq.(1-5).

Vorton is solenoid dipole 3D vorticity singularity. Velocity field generated by individual vorton.

$$\upsilon_i^{(\alpha)}(t,x) = -\frac{\epsilon_{ijk}\left(x_j - x_j^{(\alpha)}\right)\gamma_k^{(\alpha)}}{4\pi\left|x - x^{(\alpha)}\right|^3} \tag{1}$$

where ϵ_{ijk} is the unit antisymmetric tensor, and $x_j^{(\alpha)}$ (t) and $\gamma_k^{(\alpha)}$ (t) are the components of position and intensity, respectively, of the vorton labeled α.

Vorticity field of individual vorton. See solenoid dipole field picture fig.(19).

$$\Omega_i^{(\alpha)}(t,x) = \gamma_i^{(\alpha)}\delta\left(r^{(\alpha)}\right) + (4\pi)^{-1}\left(3r_i^{(\alpha)}r_k^{(\alpha)}\gamma_k^{(\alpha)} - \left|r^{(\alpha)}\right|^2\gamma_i^{(\alpha)}\right)\left|r^{(\alpha)}\right|^{-5} \tag{2}$$

Where $\delta\left(r^{(\alpha)}\right)$ is a δ-function.

Which obviously is non local field.

Vorton intensity change due to interaction with other vortons.

$$\dot{\gamma}_i^{(\alpha)} = \frac{\epsilon_{ijk}}{4\pi} \Sigma_\beta \left(r_{\alpha\beta}^{-3} \gamma_j^{(\alpha)} - 3 r_{\alpha\beta}^{-5} r_j^{(\alpha\beta)} r_m^{(\alpha,\beta)} \gamma_m^{(\alpha)} \right) \gamma_k^{(\beta)},$$ (3)

$$r_i^{(\alpha,\beta)} \equiv x_i^{(\alpha)} - x_i^{(\beta)}, r_{\alpha\beta} \equiv \left| r^{(\alpha,\beta)} \right|$$
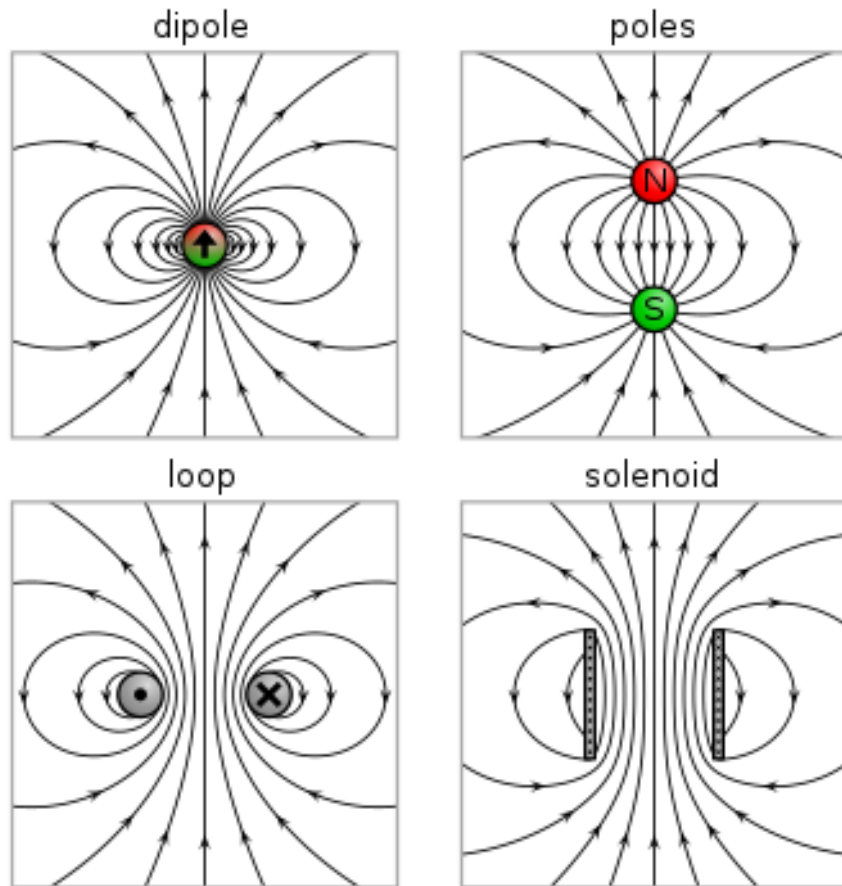
Vorton position change due to interaction with other vortons.

$$\dot{x}_i^{(\alpha)} = -\frac{1}{4\pi} \epsilon_{ijk} \Sigma_{\beta=1}^{N} {}' r_{\alpha\beta}^{-1} n_j^{(\alpha,\beta)} \gamma_k^{(\beta)},$$ (4)

$$r_i^{(\alpha,\beta)} = x_i^{(\alpha)} - x_i^{(\beta)},$$

$$r_{\alpha\beta} = \left| r^{(\alpha,\beta)} \right|,$$

$$n_i^{(\alpha,\beta)} = r_i^{(\alpha,\beta)} r_{\alpha\beta}^{-1}$$

Vorton's vorticity field, solenoid dipole. Vorticity and magnetic dipole fields [1-5,14]. Fig. 19.
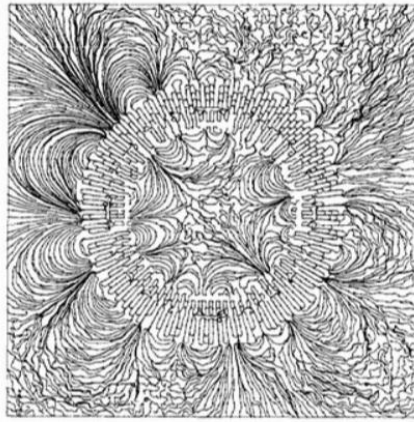
Fig. 1. Distribution of vorticity (vortex lines) in the plane of 80-vorton ring.

Vortex tube clearly seen in a vorton ring. With vortons vorticity cancelling out beyond it [3-5].
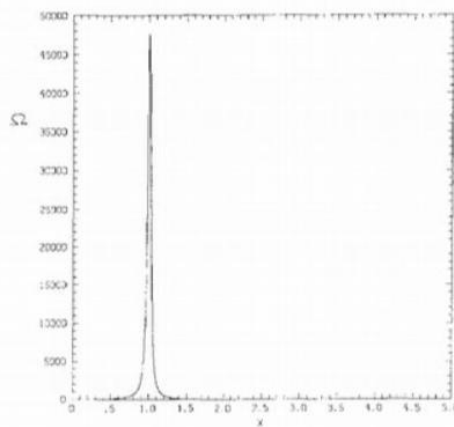

Fig. 2. Cross section of vorticity distribution in 80-vorton ring.

Non zero vorticity around radius of the ring [3-5]..

In fact we showed both analytically and numerically that chain of vortons approximates finite core vortex tubes with number of vortons corresponding to Reynolds number at hand [1-5], Fig.(1,2,19).

Another hope was that by introducing simplest solenoid vortex singularities which are analytically tractable we would be able to pass through some unknown NS "singular events" without any additional assumptions. Those events turn out to be vortex reconnections corresponding to bifurcations and branching of 3D NS solutions [1-5,29], Fig.(3-18). Both reasons appear to work out despite later vorton critiques, "modifications" and "improvements" [21-23].

Thus bifurcation and branching of Navier-Stokes solutions can be interpreted as inviscid vorton reconnections [6-9]. Very likely vortons describe dynamics on the Navier-Stokes attractor [9]. From a physical point of view vortons resolve the entire 3D vorticity field, which is superposition of 3D vortex tubes and is the only important aspect for 3D fully developed turbulence dynamics representation. And vortons showed ability to pass through NS "singular events" without any additional assumptions based on vortons inviscid dissipation ability [3-5,29].

We know from analysis that the limit of a smooth sequence of functions may not be smooth [10]. So even if Navier-Stokes solutions are all smooth, their inviscid limit could be singular. These singular inviscid solutions express the bifurcation of viscous solutions

and finite dissipation rates. Rudin's math analysis book says that limit of smooth sequence could be singular. So even if 3D NS solutions are smooth their limit/attractor could be singular/inviscid, especially if it explains all NS solutions dynamics without any additional assumptions and provide most economical/irreducible description of dynamics of 3D NS solutions for fully developed turbulence.

Hydrodynamics approach works for fluid vacuum modified Maxwell equations in inflation universe, turbulent plasma and for space-time dynamics with quantum entanglements.

Vortex singularities and inviscid energy dissipation

Singular vortex dipoles, i.e. vortons, interact according to formulas Eq.(3,4), [1- 5]. As a consequence their amplitudes may self-amplify, a reflection of vortex stretching in three dimensions.

The interaction energy of vortons is given by Eq.(6).

$$\mathcal{E}_{int} = \frac{1}{8\pi} \sum_{\alpha < \beta} r_{\alpha\beta}^{-1} \left(\gamma_i^{(\alpha)} \gamma_i^{(\beta)} + \gamma_i^{(\alpha)} n_i^{(\alpha,\beta)} \gamma_j^{(\beta)} n_j^{(\alpha,\beta)} \right) \tag{5}$$

Interaction energy of vortons [2-5].

The self-energy of a single vorton is infinite, therefore it is not included in that formula. Due to the three dimensional stretching of vortons and self amplification, the interaction energy is not conserved. We may imagine that it goes into or comes out of the infinite self-energy of individual vortons [1- 5].

In the real world this corresponds to the fact that internal rotational degrees of freedom of 3D vortices are not resolved in the interaction energy formula. The stretching energy of vortex interactions may go into or out of unresolved rotational motions. Physically energy is dissipated at small scales by viscosity, but the precise amount is determined by inviscid dynamics.

The same phenomenon occurs in shock waves in compressible fluids, and also in magnetic field reconnection in the solar atmosphere. Dissipation provides the mechanism, but inviscid dynamics governs the behavior while viscosity, diffusivity, and resistivity play mop-up roles [16-18].

We performed numerical experiments with two vorton rings executing a "leapfrogging" cycle. The rings always self-destructed after 5 periods, regardless of the number of vortons in the rings.

Multiple reconnections then happened, with small rings appearing. During the destruction of the original rings we observed a negative spike in the vorton interaction energy, and a Kolmogorov-like energy power spectrum developed. This agrees with the physical phenomena of energy transfer to small scales and inviscid dissipation of vorton interaction energy Eq.(5),

$$E_{int}(k) = \frac{1}{2\pi^2} \sum_{\alpha,\beta} \left[\phi_1(kr_{\alpha\beta}) \gamma_i^{(\alpha)} \gamma_i^{(\beta)} + \phi_2(kr_{\alpha\beta}) \gamma_i^{(\alpha)} n_i^{(\alpha,\beta)} \gamma_j^{(\beta)} n_j^{(\alpha,\beta)} \right], \tag{6}$$

$$\phi_1(z) = z^{-3}[(z^2 - 1)\sin z + z \cos z], \quad \phi_2(z) = z^{-3}[(3 - z^2)\sin z - 3z \cos z] \tag{7}$$

Vortons interaction energy as a function of wave number [2-6]. Fig.(20).
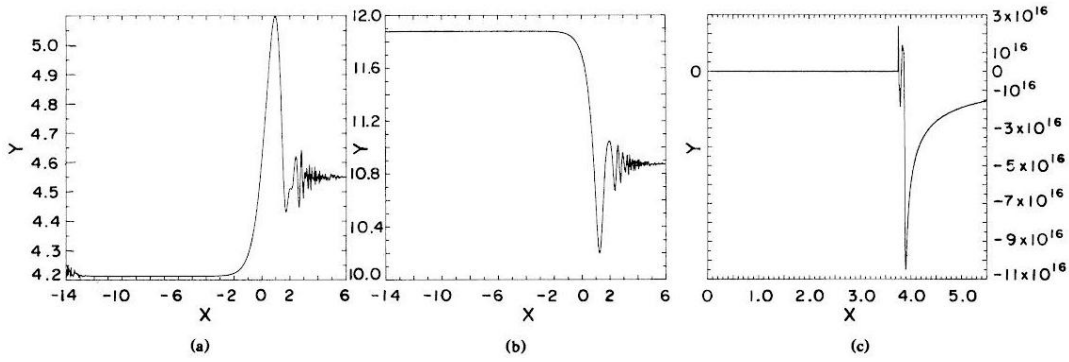
Energy spectrum of two leapfrogging vortex rings originally and at the moment of self distraction. Slope in log-log graph around -1.7. Plus negative spike in time derivative of interaction energy during distraction of the rings [2,3,5,29].

Recent experiments on colliding vortex rings show strikingly similar behavior, with large numbers of vortex reconnections and the appearance of multiple small rings [19].

3D Navier-Stokes attractor dimension

Again, in simple terms 3D NS attractor is a minimal/irreducible set, number of equations that describe dynamics of 3D Navier Stokes solutions without any additional assumptions.

A chain of vortons can approximate a vortex tube with a finite core size that is roughly equal to the distance between vortons, see Fig.(5) for a ring with 80 vortons. This observation allows us to estimate the dimension of the attractor of the 3D Navier-Stokes equations in fully-developed turbulence.

We start by assuming that the vorticity consists of one-dimensional tubes whose core size is the Kolmogorov microscale **Re^-3/4** and is a distance between neighbor vortons in a tube. Therefore the number of vortons needed to resolve such tubes is on the order of **Re^3/4**. We deduce that the dimension of the Navier-Stokes attractor is **Re^3/4**, which is the cube root of the usual Kolmogorov estimate of **Re^9/4** based on resolving the 3D velocity field with the same accuracy [1-5,13].

Magnetic vortons, hydrodynamics of turbulent plasma

The vorticity field of a vorton is identical in structure to the magnetic field of a magnetic dipole Fig.(19). In fact, in a turbulent plasma every vorton becomes magnetic due to the rotation of electrically charged plasma. So magnetic vortons interact both as a vorticity and magnetic dipoles Eq.(3,4,7).

Formula for force F between 2 magnetic dipoles **m1** and **m2** [14].

$$F = \frac{3\mu_0}{4\pi|r|^4}\{(\hat{r} \times m_1) \times m_2 + (\hat{r} \times m_2) \times m_1 - 2\hat{r}(m_1 \cdot m_2) + 5\hat{r}[(\hat{r} \times m_1) \cdot (\hat{r} \times m_2)]\} \tag{8}$$

where **μ₀** is the <u>magnetic constant</u>, $\hat{r}$ is a unit vector parallel to the line joining the centers of the two dipoles, and |r| is the distance between the centers of **m1** and **m2**.

Also, the magnetic amplitude and the vorticity amplitude will remain in a constant ratio, as they are stretched by the same fluid strain field. Formulas Eq.(3,4,7) describe the evolution of the magnetic vorton amplitude and their dipole-dipole interaction; note that there

is no self-amplification of magnetic dipole momentum through magnetic interactions since the Maxwell equations are linear [14].

In section (3) we saw that chains of vortons provide an approximation of finite-core vortex tubes. Similarly, chains of magnetic dipoles provide an approximation of finite core magnetic flux tubes, as may be observed in the Sun or in nuclear fusion experiments. Inviscid dissipation associated with reconnection of magnetic vorton tubes may be the energy source for the very high temperatures on the surface of the Sun.

Our vorton horseshoe numerical experiments show reconnection and the expulsion of vortex rings, see Figs. [1,4,5].
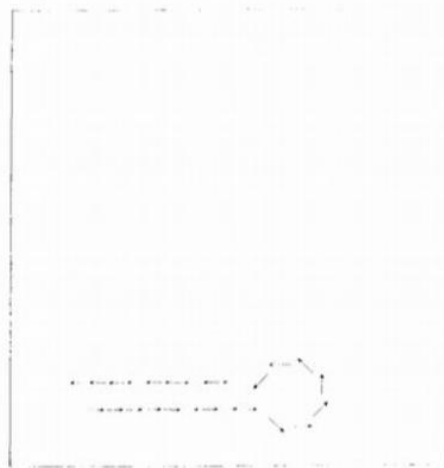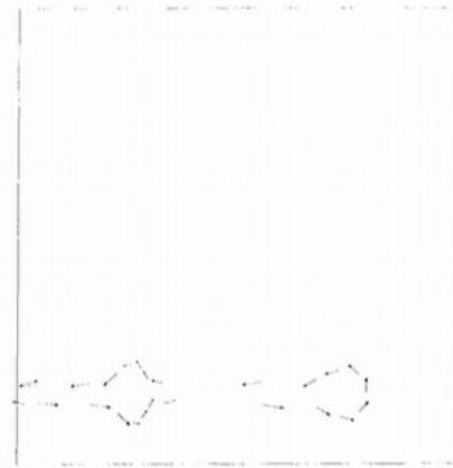

Fig. 7.   Fig. 8.

Unperturbed horseshoe vortex and it expelling vortex ring [3-5,29].
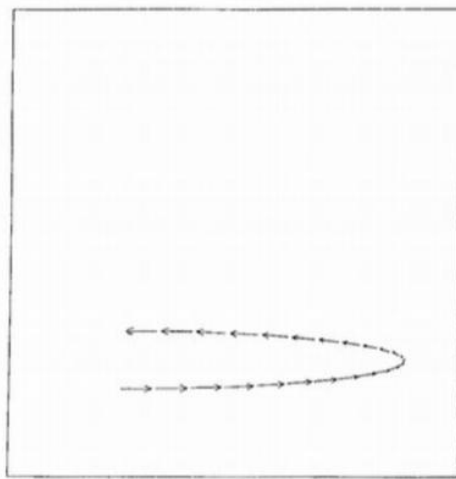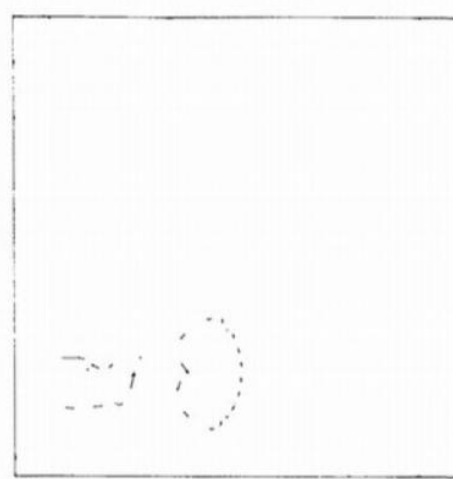

Fig. 9.   Fig. 10.

Perturbed horseshoe vortex and it expelling vortex ring [3-5].

These resemble the magnetic vortices that produce magnetic storms on Earth and disrupts magnetic confinement in plasma fusion experiments [16,17].

Appearance of magnetic vortons could be also understood based of equations for plasma turbulence similar to fluid modified Maxwell Equations presented in section 7 with viscous dissipation added and singularities of Navier Stokes less pronounced than in case of

Euler equations (singularities here are branching/bifurcations of NS solutions/reconnections).

And no need to transform corresponding equations into weak/integral form like will be necessary in equations of section 7. Notice that electromagnetism/plasma coupling constant equals 1 here in equation7.7 (see section 7 for equations).

Instability Of Vorton Collapse, Universe Inflation and "Dark Matter" Explained

As we saw in articles the system of 3 slightly non-parallel vortons almost perpendicular to 3 vortons plane (approximating 2D vortex dynamics) can start to collapse toward a point [3-5,29,59]. Just before that collapse, however, 3D vorton self-amplification commences and leads to explosive vortons amplitudes and distances growth. Fig.21
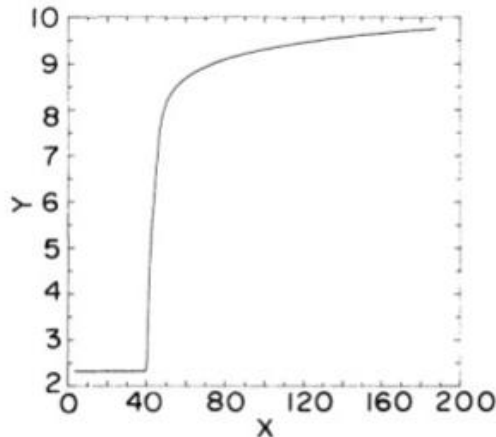
Jump in vorticity during 3 vorton collapse, LOG VORTICITY INTENSITY! against time. We have the same explosive grows in distances between vortons leading to space explosive inflationary grows and FIRST ORDER PHASE TRANSITION of vacuum compact dimensions to our quasi 3D world [2,3,29].

This could be a "turbulence" mechanism for the inflationary initial stage of the Universe expansion [15,29,59].

More precisely, imagine that the Universe starts as a point singularity fluctuation, and becomes a 2D or 3D turbulent fluid with gravity. In the 2D case gravity will collapse the Universe back to a singularity. However in 3D or quasi-3D/2D+* the vorton amplitudes and distances increase exponentially at the last stage of collapse, see Fig.(21), [3-5,29]. This may explain why our world is 3 dimensional!

A quasi 3D frisbee-like world has 2 fully-developed dimensions and 1 short dimension; it might better be described as 2D+ or "frisbee-like".

In 2D+ frisbee-like space the Universe may be slightly less complex, and have slightly more chances to fluctuate from the original singularity than a fully 3D Universe. And once gravitational collapse explodes in quasi 3D universe it will never get to any more complex spaces. Also quasi 3D/2D+ space may more naturally lead to explosive growth permitting closer vortons approach before 3D stretching and self amplification kicks in an explosive fashion. However in 2D+/quasi 3D gravitational force decays proportionally to $1/r$ at a distances from the center of galaxy much larger than the short dimension, instead of $1/r^2$ as in 3D.

A universe with two-plus dimensional structure could provide an alternative to "dark matter" as an explanation for anomalous rotation curves in galaxies. It has been observed in the edges of frisbee-like galaxies that star velocities do not depend on distance from the

center. Explicitly, setting centripetal acceleration v^2/r equal to gravitational acceleration Constant*M/r, we deduce that v must be constant in such a situation. This is a necessary condition for galactic disk stability [12,29,59].

*2D+ universe space could be imagined as two commuting dimensions and third compact one non commuting with first two. In this case initially 2D vortex collapse will become locally 3D in a last moment due to generalized uncertainty principle GUP fluctuations [46]. And explosive vortons self amplification/expansion/inflation will start at the point of collapse.

"Axes of Evil"/ hemispherical power anomaly space asymmetry could be explained as confirmation of 2D+ nature of universe [49]. In direction of short dimension we would have less stretching of space than in two larger dimensions directions and thus slightly larger temperature differences/gradients/variance.

Simulation Of Vortex Structures Dynamics and No Slip Boundary Layer

In this section we show how vorton simulations reproduce vortex structures typically observed in experiments Fig.(1-20).
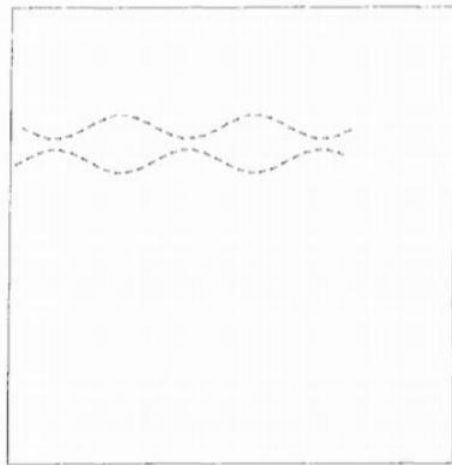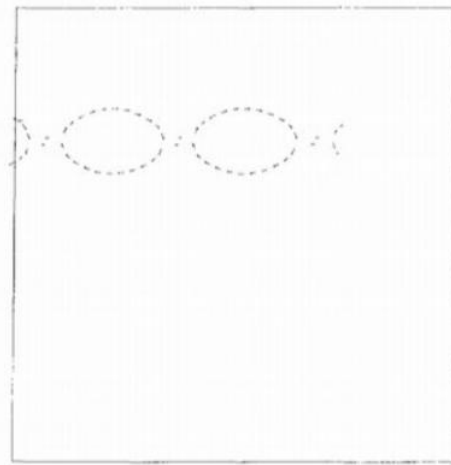

Fig. 13.   Fig. 14.

Crow instability of vortex tubes behind airplanes [3-5]. Antiparallel perturbed vortex tubes reconnect into vortex rings.
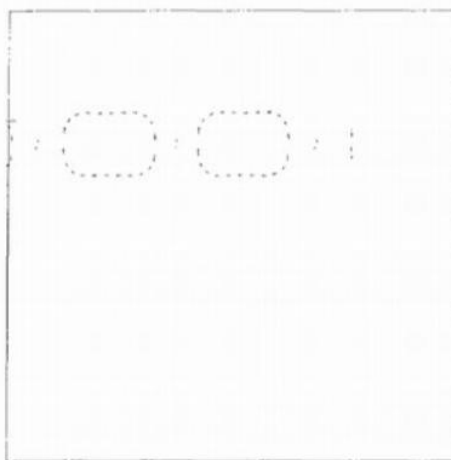

Fig. 15.   Fig. 16.

Fig. 17.

Fig. 18.
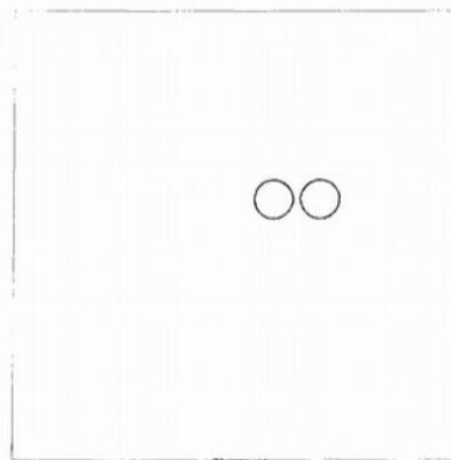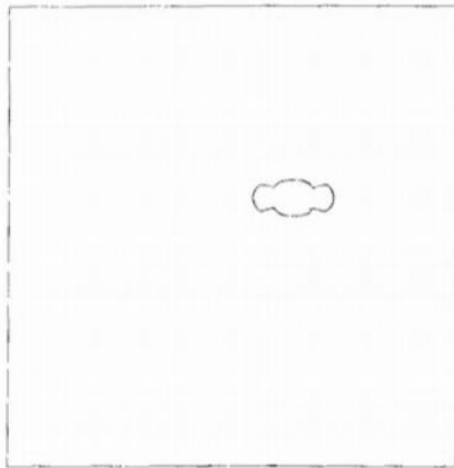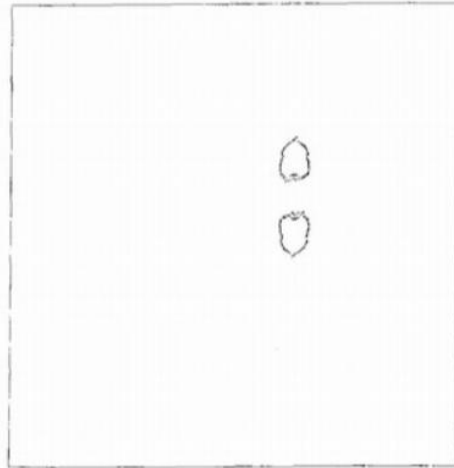
Two parallel moving vortex rings merging and splitting in perpendicular direction [3-5].
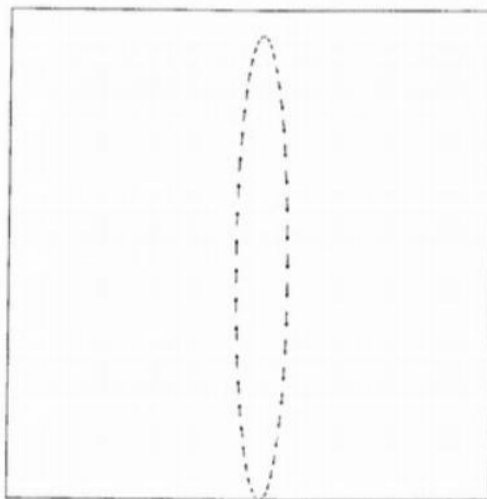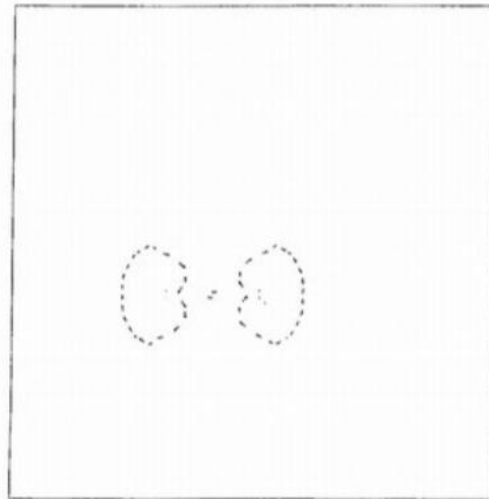

Fig. 11.

Fig. 12.

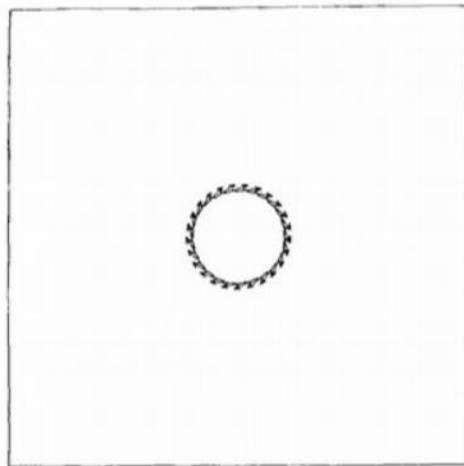Elliptic vorton ring splits into 2 rings in perpendicular direction [3-5].

Fig. 3. Reconnections of vortex filaments (see text). The scale of vortex intensities adjusts to the maximal intensity, which increases continuously. The scale of positions does not change.
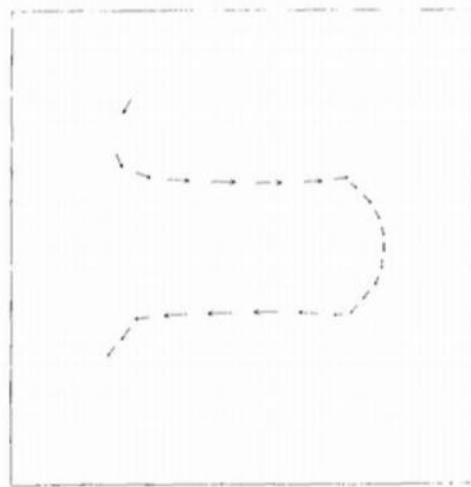

Fig. 4.

Vortex ring approaches boundary under 45 degrees angle and turns into horseshoe vortex [3-5].

We performed numerical experiments with two vorton rings executing a "leapfrogging" cycle. The rings always self-destructed after 5 periods, regardless of the number of vortons in the rings. Multiple reconnections then happened, with small rings appearing. During the destruction of the original rings we observed a negative spike in the vorton interaction energy, and a Kolmogorov-like power spectrum developed Eq.(5,6),Fig.(20). This agrees with the physical phenomena of energy transfer to small scales and inviscid dissipation of vorton interaction energy. Recent experiments on colliding vortex rings show strikingly similar behavior, with large numbers of vortex reconnections and the appearance of multiple small rings [19].

In wall-bounded flows vorticity is created via no-slip boundary conditions. We represent this process by placing arrays of vorton tubes at a distance from the wall equal to the tube core size and perpendicular to velocity and mirror image vortons to represent boundary [3-5]. The numerical scheme continues to generate vorticity at the wall to keep enforcing the no-slip condition and approximating vortex sheet at no-slip boundary. The numerical experiments show that perturbations on the tubes then expel vortex rings into the flow away from the wall Fig.(5,6).

Fig. 5.   Fig. 6.
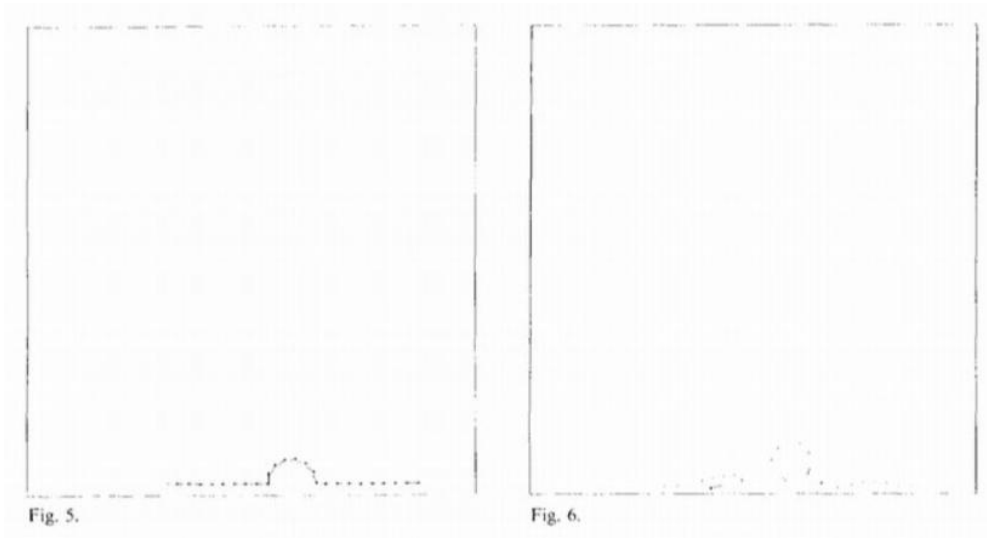
Perturbed vortex tube near the wall and it expelling vortex ring [3-5].

Using modern fast multipole numerical schemes to simulate vortex dynamics we can come up with number of necessary calculations per time step for boundary layer simulation where typically number of operations proportional to **n*ln(n)=(Re^3/4)*ln(Re)**, when in our case number of vortices/vortons n is **Re^3/4** [1-5,11].

Fluid Vacuum Modified Nonlinear Maxwell Equations

The wave functions of elementary particles are often interpreted as probability amplitudes. When they take the form of Gaussian distributions for isolated particle, they look very much like test functions for generalized solutions of unknown nonlinear equations.

Maxwell equations are linear and we don't expect any spontaneous singularities there starting with smooth initial conditions and thus no singular solutions expected there. However if by analogy to previous section 5 we assume original vacuum to be very dense and fluid (quark gluon plasma for example) we may modify Maxwell equations for fields and charges to be advected, frozen in fluid vacuum.

Thus we have following modified electromagnetism equations,

$$\nabla \cdot \overline{E} = \frac{\rho}{\varepsilon_0} \tag{7.1}$$

$$\nabla \cdot \overline{B} = 0 \tag{7.2}$$

$$\nabla \times \overline{E} = -\frac{d\overline{B}}{dt} \tag{7.3}$$

$$\nabla \times \overline{B} = \mu_0 \left(\bar{J} + \varepsilon_0 \frac{d\overline{E}}{dt} \right) \tag{7.4}$$

$$\frac{d\rho}{dt} = 0 \tag{7.5}$$

$$\frac{d\bar{J}}{dt} = 0 \tag{7.6}$$

$$\frac{d\overline{V}}{dt} = -\nabla \left[\frac{\propto}{2} \left(\varepsilon_0 E^2 + \frac{B^2}{\mu_0} \right) + \frac{g^2}{8\pi G} \right] \tag{7.7}$$

$$\nabla \cdot \overline{V} = 0 \tag{7.8}$$

Where in original Maxwell equations we substituted total/advective derivatives instead of partial time derivatives and all the fields and charges are frozen in vacuum fluid and being advected [37,29].

Vacuum itself satisfies incompressible Euler equation (only transverse waves propagate there) [37,29]. And Euler equation (7.7) represents in right hand side gradient of energy density/dynamic pressure of electromagnetic and gravity fields [36,37]. And alpha is electromagnetism/vacuum coupling constant (around 1/173), which originally could have been closer to 1.

After instability/inflation/First order phase transition of vorton collapse created quasi 3D space out of original curled/compact vacuum dimensions we could observe that 3D Euler equation with vorticity develops spontaneous vortex like singularities due to nonlinear stretching/self amplification on time scale of vortex rotation. Thus above nonlinear Maxwell equations transform into weak/integral form with corresponding smooth test functions in order to pass through Euler equation singularity [32]. As a consequence electromagnetic field and charges also become singular being subject to the same rate of strain as vorticity and being frozen into vacuum fluid.

As a final result we have singular/generalised solutions/"particles" with vorticity/spin and singular electric charge or electromagnetic field and with smooth test function distribution which squared could be interpreted as a probability density function.

Charged singularities with vorticity/angular momentum/spin and spatially distributed according to test function develop magnetic moment.

Here we have possible explanation of quantum mechanics properties of elementary particles. More details of actual elementary particles parameters are connected to influence of remaining compact vacuum dimensions with corresponding symmetries and entanglements and discrete nature of vacuum at the Planck scale.

Conclussions and Discussion

Using "vortons", i.e. discrete solenoid vortex dipole elements, essentially solves the problem of the most economical description 3D Navier Stokes equations and their solutions at Reynolds numbers above few thousands. Vortons irreducibly describe the physics of 3D vortex and magnetic vortex structures, providing dynamics on inviscid 3D Navier Stokes attractor scaling with corresponding Reynolds number. Instability/"inflation" of vorton collapse in quasi 3D space is proposed as an explanation of aspects of the origin of the Universe and phenomena attributed to "dark matter" and "dark energy" [29,39]. Magnetic vortons provide dynamics of combined vortex and magnetic tubes in plasma including reconnections. No-slip boundary shown as a source of vorticity at the boundary and inside the flow. Plus in the process of self distraction of 2 leapfrogging vortex rings and subsequent reconnections we observed Kolmogorov like power law energy spectrum and energy cascade towards small scales.

In terms of cosmology results vorton system provides unique self amplification explosive nonlinear mechanism to explain early universe inflation/First order phase transition and current accelerated expansion with purely dimensional explanation of dark matter without need for dark matter detection efforts. Also it explains results of MOND gravity theory, based on space dimensional structure, which similarly implicitly assumes 1/R gravity force in galaxies far from the center. And finally First order phase transition/inflation of original compact vacuum space to our quasi 3D physical space during universe explosive expansion leads to fluid vacuum induced appearance of spontaneous singularities in electromagnetism and weak/integral formulation which in turn explains appearance of elementary particles and their probabilistic distribution based on test function of generalized/weak solutions of fluid vacuum modified nonlinear Maxwell Equations.

Spontaneous singularities in Navier Stokes and Euler equations lead to original smooth initial conditions turning into many body/" interacting singularities" problem.

A few ideas underpin this work:

3D Euler and Navier Stokes equations develop spontaneous singularities based on vorticity self-amplification. Note that the Euler equation requires transformation to weak/integral form to pass through the singularity.

Fluid vacuum or plasma are advected by 3D turbulence, and everything is locally subject to the same rate of strain as vorticity.

In the case of cosmological inflation, we have a time scale of 10^{-32}**sec**, which is much faster than any physical process time scale of fastest 10^{-25}**sec**. Instantaneous snapshots of these processes at inflation time scale could be very different from their typical results due to GUP fluctuations asymmetries at that time scale.

There appears to be several interconnected events during exponential space inflation/first order phase transition. First it was instability of quasi 3D vorticity/vortons collapse driving universe expansion (much faster than the speed of light) with vorticity frozen into fabric of space while creating that space. That exponential inflation drove space far beyond causality horizon preserving original causal relationships, thus explaining resulting entanglements [47,50,59]. Again, these parts of space behave as original compact vacuum degrees of freedom through entanglements [29,47,50,59].

We can see that exponential inflation breaks several physics results if not physics laws per se. Plus hydrodynamics of quantum space-time introduces new covariant divergence term into original Einstein's general relativity equations, thus removing singularity of those equations and necessity of Big Bang.

Simple linear algorithm suggested for Early Bifurcation/Regime shift detection in nonlinear, non equilibrium, non stationary systems using linear statistical moments approximations/equivalents formulas where used in proprietary statistical programs

REFERENCES

1. E. A. Novikov, Zh. Eksp. Teor. Phys. 84, 975 (1983) [Sov. Phys. JETP 57, 566 (1983)].
2. M.I. Aksman. E.A. Novikov and S.A. Orszag. Phys. Rev. Lett. 54 (1985) 2410.
3. M.I. Aksman, Vortex method in three-dimensional hydrodynamics, MIT thesis, 1985.
4. Aksman, Novikov. 1988 Fluid Dynamics Research, Volume 3, Issues 1–4, pdfslide.net/documents/reconnections-of-vortex-filaments.
5. Aksman, University of Arizona preprint, M.I. Aksman and E.A. Novikov. Metamorphoses of three-dimensional vortex structures. Preprint 87-l. University of Arizona (1985).
6. Leray 1934, journals/acta-mathematica/volume-63/issue-none/Sur-le-mouvement-dun- liquide-visqueux-emplissant-lespace/
7. R. Temam, Navier-Stokes Equations (North-Holland. Amsterdam, 1979).
8. O.A. Ladyzhenskaya. The Mathematical Theory of Viscous Imcompressible Flow (Gordon and Breach. NJ.. 1969).
9. Carvalho, A.; Langa, J.A.; Robinson, J. (2012). Attractors for infinite-dimensional non- autonomous dynamical systems. Vol. 182. Springer. p. 109
10. Rudin, Principles_of_Mathematical_Analysis.
11. Gibson, Walton C. The Method of Moments in Electromagnetics (3rd ed.), Chapman & Hall/CRC, 2021
12. Galactic Astronomy, Dmitri Mihalas and Paul McRae. W. H. Freeman 1968.
13. A. S. Monin and A. M. Yaglom, Statistical Fluid Mechanics: Mechanics of Turbulence, edited by John L. Lumley
14. Malcolm H. Levitt, Spin Dynamics: Basics of Nuclear Magnetic Resonance
15. Weinberg, Steven (2008). Cosmology. Oxford University Press
16. Mackay, D. H.; Karpen, J. T.; Ballester, J. L.; Schmieder, B.; Aulanier, G. (April 2010). "Physics of Solar Prominences: II – Magnetic Structure and Dynamics". Space Science Reviews. 151 (4): 333–399. arXiv:1001.1635
17. Magnetic_confinement_fusion . Williams, F. A. (2018). Combustion theory. CRC Press.
18. R Williams, F. A. (2018). Combustion theory. CRC Press. Rankine–Hugoniot conditions.
19. Emergence of small scales in vortex ring collisions Mónico1,2, Alain Pumir3,
20. C. Romero and F. Dahia, THEORIES OF GRAVITY IN 2+1 Dimensions, PREPRINT 2 3-93 D.F. /CCEN-·UFPB
21. A Model of Interacting Navier–Stokes Singularities 2022, Hugues Faller et all.
22. Saffman P.G., Meiron D.I. Difficulties with three-dimensional weak solutions for inviscid incompressible flow. Phys. Fluids. 1986;29:2373–2375. doi: 10.1063/1.865529.
23. Alkemade A.J.Q., Nieuwstadt F.T.M., van Groesen E. The vorton method. Appl. Sci. Res. 1993;51:3–7. doi:

10.1007/BF01082505.

24. Electromagnetic properties of the quantum vacuum calculated from its structure G. B. Mainland and Bernard Mulligan

25. Fluid Mechanics Explains Cosmology, Dark Matter, Dark Energy, and Life, Carl H. Gibson.

26. grc.nasa.gov/www/k12/Numbers/Math/Mathematical_Thinking/A Possible Scalar Term Describing Energy Density in the Gravitational Field

27. ui.adsabs.harvard.edu/abs/1975Ap%26SS..34..249M/abstract. Turbulence in Cosmology. I: The Effect of the Strong Turbulence on the Early Evolution of the Universe, Marochnik, L. S. ;Pelikhov, N. V. ; Vereshkov, G. M,1975

28. Moment_(mathematics, statistics)

29. Aksman Mikhail. Vortons Revisited. 2025. ffhal-04575213

30. Dekking, Frederik Michel; Kraaikamp, Cornelis; Lopuhaä, Hen Paul; Meester, Ludolf Erwin (2005). A Modern Introduction to Probability and Statistics.

31. Milgrom, M. (1983). "A modification of the Newtonian dynamics as an alternative to the hidden mass hypothesis". Astrophysical Journal. 270: 365–370.

32. Evans, L. C. (1998). Partial Differential Equations. Providence: American Mathematical Society.

33. First Second of the Big Bang". How The Universe Works 3. 2014. Discovery Science.

34. Peebles, P. Z., 2001, Probability, Random Variables and Random Signal Principles, McGraw-Hill Inc, Boston

35. Misner, Charles W.; Thorne, Kip S.; Wheeler, John Archibald (1973). Gravitation. San Francisco: W. H. Freeman.

36. L. J. Clancy (1975), Aerodynamics, Pitman Publishing Limited, London

37. Chorin, Alexandre J.; Marsden, Jerrold E. (2013). A Mathematical Introduction to Fluid Mechanics. Springer.

38. Harrison, Edward R. (2000). Cosmology: the science of the universe (2nd ed.). Cambridge: Cambridge University Press.

39. Implications of Symmetry and Pressure in Friedmann Cosmology. III. Point Sources of Dark Energy that Tend toward Uniformit

40. Scheffer, Marten (26 July 2009). Critical transitions in nature and society. Princeton University Press.

41. Horodecki, Ryszard; Horodecki, Pawel; Horodecki, Michal; Horodecki, Karol (2009). "Quantum entanglement". Reviews of Modern Physics

42. Sean Carroll Entangles Time and Entropy

43. preposterousuniverse.com/blog/2016/07/18/space-emerging-from-quantum- mechanics/

44. "First Second of the Big Bang". How The Universe Works 3. 2014. Discovery Science.

45. encyclopediaofmath.org/Edgeworth_series

46. Adler, Ronald J.; Santiago, David I. (1999). "On Gravity and the Uncertainty Principle". Modern Physics Letters A. 14 (20): 1371–1381.

47. astronomy.com/science/could-quantum-entanglement-be-a-result-of-the-big-bang/

48. Hubble law

49. Land, Kate; João Magueijo, João (2005). "Examination of Evidence for a Preferred Axis in the Cosmic Radiation Anisotropy". Physical Review Letters. 95 (7): 071301.

50. Vortons in Fluid Mechanics, Magnetohydrodynamics, and Cosmology, /abs/2304.0091

51. arxiv.org/abs/nlin/0608050. Vacuum response to cosmic stretching: accelerated Universe and prevention of singularity, E. A. Novikov

52. Emergence of the Laws of Nature in the Developing Entangled Universe, Evgeny A. Novikov

53. arxiv.org/abs/1012.0241 Hydrodynamic Vacuum Sources of Dark Matter Self-Generation in Accelerated Universe without

Big Bang, S. G. Chefranov, E. A. Novikov

54. researchgate.net/publication/377314862_Gravitational_Waves_Background

55. Quantum Capacity and Vacuum Compressibility of Spacetime: Thermal Fields, Hing- Tong Cho, Jen-Tsung Hsiang, Bei-Lok Hu

56. Maldacena, Juan; Susskind, Leonard (2013). "Cool horizons for entangled black holes". Fortschritte der Physik. 61 (9): 781–811.

57. PHYSICAL REVIEW D 111, 066001 (2025), Gravity from entropy, Ginestra Bianconi

58. Are dark matter and dark energy omnipresent?, Richard Lieu

59. Deep Photometry of Suspected Gravitational Lensing Events: Potential Detection of a Cosmic String

60. grc.nasa.gov/WWW/K-12/airplane/machrole

Appendix Section 1. Gravity And 3d Physical Space As A Result Of Instability Of 3d Vorton Collapse /Inflation

In approximately 10^{-32}sec original compact vacuum space exponentially inflated/expanded by a factor of at least 10^{30} into our current 3D physical space by mechanism of instability of quasi 3D/2D+ vorton collapse that was much faster than a speed of light Refs(41-43) and inflated space went beyond causality horizon of original vacuum space. Thus original compact vacuum space entanglements persisted in our current 3D space, possibly explaining gravity.

Baryon asymmetry Quark antiquark annihilation happens on 10^{-25}sec time scale and universe inflation happend on 10^{-32}sec time interval which probably explains some quark antiquark initial instantaneous imbalance at 10^{-9} baryons/photons ratio level Ref.(44).

And it could be explained similarly to CMB inhomogeneities as being inflation magnified instant GUP (generalized uncertainty principle) Ref.(46) Gaussian fluctuations of quark antiquark annihilations at the instant right before inflation commenced.

Due to instantaneous snapshot of Gaussian distribution at time scale of inflation 10^{-32}sec we may have instantaneous nonzero skewness and kurtosis moments/cumulants even at the normal fluctuations and appropriate coefficients in Edgeworth Series moments/cumulants expansion by statistical moments Ref.(45). It's next order to CMB Edgeworth expansion which is due to variance in Edgeworth Series, and could be seen in CMB fluctuations results at 10^{-5} level Ref.(45). Here first/variance term in Edgeworth expansion is cancelled because of quark and antiquark fluctuations both being normally distributed with equal variance.

Appendix section 2. dark energy and the expansion of the universe refs.(24-27). "antigravity" as an emergent property of vortons nonlinear interaction.

Instability of vorton quasi 3D/2D+ collapse that created our quasi 3D space during inflation/First order phase transition and thus vorticity probably is frozen into the fabric of space and is driving expansion through vortons interaction. Plus if space expansion dilutes mass it in turn stretches vorticity filaments frozen into fabric of space and thus amplifying their intensity Ref.(59). If we observe Eq.(6) for vorton interaction energy we can see that in order for that energy to stay limited in spite of unlimited self amplification of vorton intensities we need distances between vortons to keep increasing. That may explain repulsive/"antigravity"/"dark energy" vortons interaction effect.

As we saw in the previous chapters, the instability of 3D vorton collapse leads to self- amplification and explosive expansion of vorton amplitudes and distances Ref.[1- 5,29]. An interesting fact is that until 5 billion years ago the Universe's expansion was decelerating, but since then the expansion has accelerated Ref.[15]. There is an antagonism between gravity pushing toward contraction and turbulent 3D vorticity interaction pushing toward expansion of Universe. More precisely, the gravitational field consists of monopoles leading to a $1/r^2$ strength falloff. Meanwhile vorticity is a dipole or quadrupole field with falloff proportional to $1/r^3$ or faster. So in the early Universe gravity dominated vorticity interactions. But later vorticity self-amplification due to 3D stretching led to dominance of the vorticity interactions and accelerated the Universe's expansion, with gravity having no self amplification mechanism due to linearity of

corresponding equations. This observation is attributed to a mysterious "Dark Energy", which may simply be a manifestation of vorton self and interaction energy. In section 1 we interpreted the infinite self-energy as belonging to unresolved internal rotational degrees of freedom of individual vortons. So the dark energy responsible for the accelerating Universe expansion is simply the transfer of internal rotational energy into interaction energy of the system of vortons plus the transfer of gravitational potential energy in there. Gravity by squeezing vorticity closer intensifies vortex interaction and stretching, self amplification and thus vorton interaction energy.

Energy is conserved. As the vorton interaction energy, and thus dark energy, increases, we expect a corresponding decrease in gravitational interaction/potential energy. In the 3D case the gravitational potential energy of universe is -(const)*(M^2)/r, while in the 2D it is (const)*(M^2)* ln(r), where M is universe's gravitationally interacting mass and r is its radius Ref.[20] and constants obviously are not the same. In the intermediate 2+D case we may be closer to the 2D or 3D formula depending on how much the third short dimension is developed compared to the two fully developed dimensions.

In fact we have age of universe about 14B years and visible universe about 46B light years which means mass dilution of currently gravitationally interacting universe mass by factor of about 35 times due to expansion faster than a speed of light Ref.(38), which means that potential gravitational energy of universe decreases with time leading to corresponding increase in vortons/turbulence interaction energy.

Dilution of mass density due to rapid expansion obviously decreases universe contraction factor in Einstein field equation Ref.(35). Space expansion on the other hand stretches/amplifies vorticity/vorton filaments, which are frozen into the fabric of space due to them creating our universe space in a first place by quasi 3D vorton collapse instability/inflation.

By inspection Eq. (5) for vortons interaction energy we can see that vorton interaction energy is proportional to product of intensities and inversely proportional to distances between vortons. In expanding universe as we pointed above, vortons intensities grow linearly as well as distances grow linearly proportionally to universe expansion rate. Thus total interaction energy end up growing linearly with distances in expanding universe by above equation.

We also suspect that the short dimension became more fully developed 5B years ago when the Universe expansion changed from decelerating to accelerating. The gravitational energy released from expansion "regime shift" went into the interaction energy of vortons associated with "dark energy". The above mentioned gravitational potential energy formula then became closer to the 3D case.

Also in fully 3D physical space case as compared to 2+D case we have much stronger vorticity stretching with corresponding vorticity intensity self amplification and with commensurate vortons interaction energy increase. So that central part of frisbee like universe may expand faster than the rest leading to short dimension approaching two larger dimensions.

Aforementioned expansion rate variability may explain so called "Hubble tension" Ref.(48).

Appendix section 3. Early bifurcation/regime shift detection in non equilibrium nonstationary systems using linear statistical moments approximations/equivalents formulas.

As we saw in Section.7 were regime shift Ref.(40) happened between universe decelerated to accelerated expansion, we need algorithm for early detection in such situations. Every physicist, climatologist, statistician, economist, and market trader hopes to being able to predict bifurcations/regime shifts in the non equilibrium non stationary systems they're studying. Climate, for example, may undergo sudden dramatic change/regime shift which obviously needs early detection. Or Gulf Stream may suddenly disappear with NORTHERN EUROPE TURNING INTO SIBERIA!

Of course perfect prediction is impossible, but early detection of indications could still be very useful. Metrics used for detection have included statistical moments such as standard deviation, skewness, and kurtosis. A problem with these metrics is that they are defined as higher degree polynomials Ref.(28). The calculations require many data points for high accuracy. By the time these metrics are reliably calculated they may no longer be useful

for detection. Taking data more frequently does not help, as a system may have different dynamics at different time

scales.

An alternative approach is to use approximations/equivalents to higher order moments, that are first order but still capable of capturing volatility, asymmetry, and tails spread characteristics of the distribution.

1. Standard deviation:

a. IQR,

b. Range=(H-L),

c. (H-L)/(H+L).

2. Skewness:

a. (Q(75%)+Q(25%)-2*median))/IQR

b. (H+L-2*median)/(H-L)

c. (mean-median)/IQR

3. Kurtosis

(H-L)/IQR

Where IQR is interquantile range Ref.(30), H an L are process interval high and low, Q(%) is corresponding percentage quantile.

We may add measure of stationarity of the process, Variance=Std^2.

And the ratio of variances for double time interval and original time interval will be 2 for random walk and 1 for stationary process (assuming constant normalized standard deviation). With our real process at hand somewhere in between.

We may have two uses for above formulas:

1. As a regime shift detected manually.

2. As an automated switch made by some ML system with all above indicators given as an input.

In both cases expert system then may start training on our system historical data assuming relative statistical stability, stationarity and ergodicity Ref.(34) of data between system bifurcations/regime shifts.

Metrics used for detection have included statistical moments such as standard deviation, skewness, and kurtosis, high and low, which are important integral statistical characteristics of a whole time interval of the process.

Again most of real world systems are "open" systems with energy/information exchange with outside, thus we don't expect stationarity/equilibrium/mean reversion and they will bifurcate and switch regime and in our case of only statistical description of these systems we have to settle for early statistical detection of those shifts.

Appendix section 4. Hydrodynamics of space-time, quantum modified general relativity.

Original physics explanations of derivation of quantum modified general relativity Qmoger equations in Refs.(51-56) are not very straightforward/compelling. On the other hand original derivation of Maxwell equations was based on some farfetched mechanical models. So as in many other cases equations turn out to be "smarter " than their original inventors. Here is possible physics behind those quantum modified general relativity equations Refs.(51-56).

We may start with noticing that universe exponential inflation happened at faster than the speed of light (superluminal speed). And original compact vacuum degrees of freedom got expanded into our space/universe beyond causal horizon, thus creating entanglements.

In fact any entanglements (or even possible wormholes EP=EPR Ref.(56)) create conditions for superluminal propagation of disturbances.

And there are two interpretations of relativity principles. First, that superluminal propagation of disturbances is impossible. And second, possible, being Lorentz invariant. And Qmoger theory is fully covariant including newly added covariant divergence of space- time Refs.(51-56).

With superluminal/supercausal propagation of space-time disturbances we have longitudinal/ "compression" space-time waves (not of space itself, where only transverse waves are possible). Longitudinal waves mean compressibility of space-time and appearance of sources/sinks and creation/absorption of mass/energy and thus removing singularity of those equations and necessity for Big Bang. Still this theory is only viable in dimensions 3+1 Refs.(51-55) and only explanation of appearance of our 3D space/universe is aforementioned instability of 3D vorton collapse/inflation.

And this theory means that universe appears to be open thermodynamic system and energy and mass are not preserved, unlike in original general relativity Ref.(35). Longitudinal waves of space-time predicted there could be experimentally detected Ref.(54).

New entanglements entropy based general relativity modification theory Ref.(57) logically should provide the way to calibrate coefficient at the new additive covariant divergence term in Qmoger quantum modified general relativity equations. Somewhat similar paper on sources/sinks like singularities of space time and creation/absorption of mass/energy just appeared Ref.(58).

Introducing light speed related Mach number M for longitudinal/compression space-time waves and for isentropic (constant rate of quantum entanglements) flows we have below formula Ref.(60). In case of universe expanding with Hubble constant rate H we have as a result of equation below decay of mass/energy vacuum density at $\exp(-M^2H^3t)$ rate.

Mach Number
Role in Compressible Flows

Glenn Research Center

V = velocity   p = pressure   T = temperature   a = speed of sound

ρ = density   M = Mach   R = gas constant   γ = specific heat ratio

Conservation of Momentum: $\quad \rho\, V\, dV = -\, dp$

Isentropic Flow: $\quad \dfrac{dp}{p} = \gamma\, \dfrac{d\rho}{\rho}$

$$dp = \gamma\, \frac{p}{\rho}\, d\rho = \gamma\, R\, T\, d\rho$$

$$dp = a^2\, d\rho$$

Combine with Momentum: $\quad \rho\, V\, dV = -\, a^2\, d\rho$

$$-\, M^2 \frac{dV}{V} = \frac{d\rho}{\rho}$$
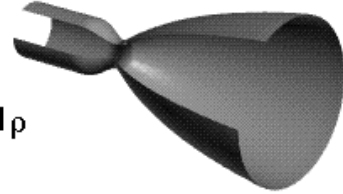
For subsonic flow (M < 1), density is relatively constant

For transonic flow (M ~ 1), density change is nearly equal to velocity change

For supersonic flow (M > 1), density changes faster than the velocity by a factor of M^2

20